COLUMNS

Design of axially loaded columns

Q: Design a square, rectangular and circular column to carry an axial load of 1200kN, $f_{ck} = 20$, $f_y = 415$.

Ans:

(i) **Square column**

axial load $P = 1200\ kN$

factored load $P_u = 1200 \times 1.5 = \underline{1800\ kN}$

From Pg: 71 (Cl. 39.3),

$$P_u = 0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_{sc} \quad \text{——— (1)}$$

let A_g = gross area = $A_{sc} + A_c$

Assume A_{sc} = 1% of A_g = $0.01\, A_g$

$$A_g = 0.01\, A_g + A_c$$

$$\therefore A_c = 0.99\, A_g$$

Substituting in (1): $1800 \times 10^3 = 0.4 \times 20 \times 0.99\, A_g + 0.67 \times 415 \times 0.01 A_g$

$$\Rightarrow A_g = 168216\ mm^2$$

$\therefore$ side of column = $\sqrt{168216}$

= 410 mm

Let the column size be 400mm x 400mm.

* Determining A_{st}

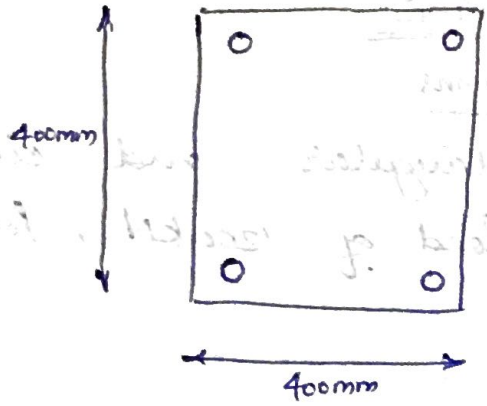
$$P_u = 0.4\, f_{ck}\, A_c + 0.67\, f_y\, A_{sc}$$

$$1800 \times 10^3 = 0.4 \times 20\,(400 \times 400 - A_{sc}) + 0.67 \times 415\, A_{sc}$$

$$\therefore A_{sc} = \underline{1925.57\ mm^2}$$

Providing 25mmϕ, no: of bars = $\dfrac{1925.57}{\pi/4 \times 25^2} \approx \underline{4\ bars}$

Nominal cover = 40mm.



∴ c/c dist: b/w adjacent reinforcements

$= 400 - (40 \times 2) - \left(\frac{25}{2} \times 2\right)$

$= 295\ mm$

According to Cl. 26.5.3.1(g), it should be $\leq 300mm$ (Pg: 48) ∴ OK

% longitudinal steel $= \frac{A_{sc}}{A_g} \times 100$

$= \frac{4 \times \pi/4 \times 25^2}{400 \times 400} \times 100$

$= 1.23\%$

It is $> 0.8\%$ and $< 6\%$ ∴ OK {as per Cl. 26.5.3.1(a) Pg: 48}

* Design of lateral ties

Diameter of lateral ties = (i) $1/4 \times 25 = 6.25\ mm$ ✓

(ii) $\geq 6mm$

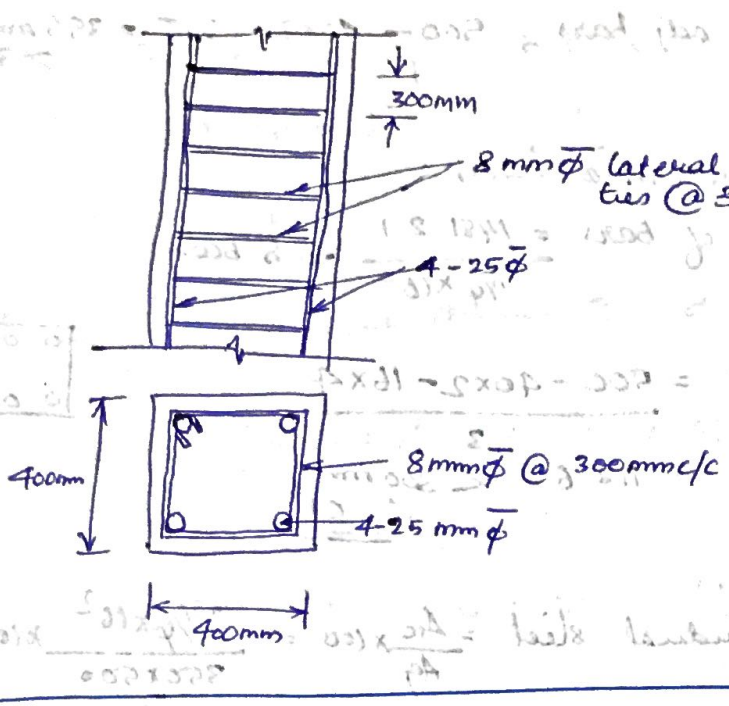
∴ Provide 8mm ϕ lateral ties.

Pitch = (i) 400mm

(ii) $16 \times 25 = 400\ mm$

(iii) 300mm ✓ (minimum is selected)

∴ Provide 8mm lateral ties @ 300mm c/c.



(ii) Rectangular column

$P_u = 1800\ kN$

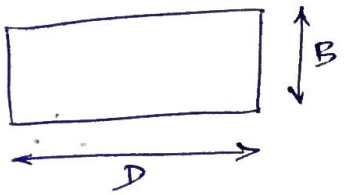
Let $A_g = A_c + A_{sc}$

& $A_{sc} = 0.01\ A_g$ $\Rightarrow$ $A_c = 0.99 A_g$

$P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{sc}$

$1800 \times 10^3 = 0.4 \times 20 \times 0.99 A_g + 0.67 \times 415 \times 0.01 A_g$

$A_g = 168216\ mm^2$



let $D = 1.5B$

$\therefore BD = 168216$

$B \times 1.5B = 168216$

$\therefore B = 334.8\ mm$

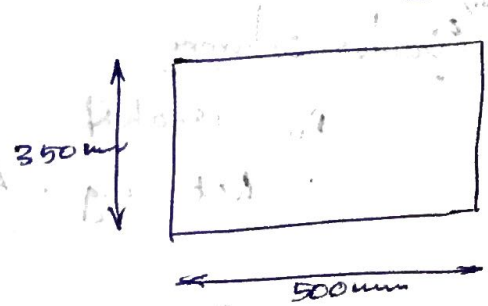
$\therefore$ Let $B \approx \underline{350\ mm}$ $\Rightarrow$ $D = 1.5 \times 350 \approx 525$

$\approx \underline{500\ mm}$

$P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{sc}$

$1800 \times 10^3 = 0.4 \times 20 \times (500 \times 350 - A_{sc}) + 0.67 \times 415\ A_{sc}$

$\therefore A_{sc} = \underline{1481.21\ mm^2}$

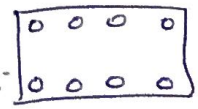


no: of bars $= \dfrac{1481.21}{\pi/4 \times 25^2} = 3.02 \approx 4$ bars

c/c dist : b/w adj bars = $500 - 40\times2 - 25 = 395$ mm
> 300 m
∴ not possible

∴ Let's use 16mmϕ bars,

∴ no: of bars $= \frac{1481.21}{\pi/4 \times 16^2} \approx 8$ bars



c/c dist $= \frac{500 - 40\times2 - 16\times4}{3}$

$= 118.67 < 300$ mm

∴ OK

∴ % Longitudinal steel $= \frac{A_{sc}}{A_g} \times 100 = \frac{8\pi/4 \times 16^2}{350\times500} \times 100$

$= 0.92\%$.

it is $> 0.8\%$ and $< 6\%$.

∴ OK

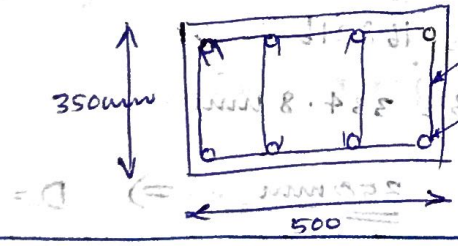
* Design of lateral ties

ϕ = (i) $1/4 \times 16 = 4$ mm
(ii) ≥ 6 mm ✓

∴ Provide 8mmϕ lateral ties.

pitch = (i) 350 mm
(ii) $16 \times 16 = 256$ mm ✓
(iii) 300 mm

∴ Provide 8mmϕ lateral ties @ 250mm c/c



(iii) Circular columns

$P_u = 1800$ kN

∴ let $A_g = A_c + A_{sc}$ and $A_{sc} = 0.01\ A_g$

$A_c = 0.99\ A_g$

$P_u = 0.4\ f_{ck}\ A_c + 0.67\ f_y\ A_{sc}$

$1800 \times 10^3 = 0.4 \times 20 \times 0.99\, A_g + 0.67 \times 415 \times 0.01\, A_g$

$\therefore A_g = 168216\ mm^2 = \pi/4\, D^2$

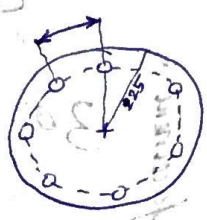
$\therefore D = 462.8\ mm$

$\therefore$ Assume circular column of diameter 450 mm

$1800 \times 10^3 = 0.4 \times 20 \times (\pi/4 \times 450^2 - A_{sc}) + 0.67 \times 415\, A_{sc}$

$\therefore A_{sc} = 1953.9\ mm^2$

Providing 16mmϕ, no. of bars $= \dfrac{1953.9}{\pi/4 \times 16^2} \approx 7$ bars.



c/c dist b/w bars measured along periphery of column $= \dfrac{(225 - 40 - 16/2)\, 2\pi}{7}$

$= 158.87\ mm < 300\ mm$ $\therefore$ OK

$\%$ reinf $= \dfrac{7\pi/4 \times 16^2}{\pi/4 \times 450^2} \times 100 = 0.88\%$

It is $> 0.8\%$ & $< 6\%$ $\therefore$ OK

* Design of lateral ties

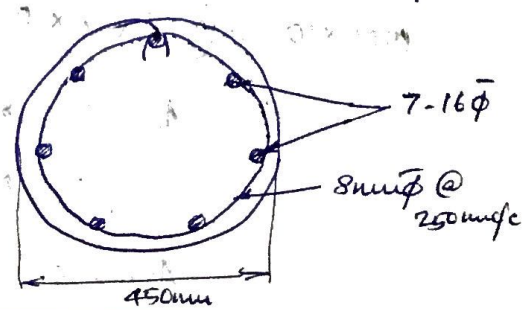
ϕ = (i) $1/4 \times 16 = 4\ mm$

(ii) $\geq 6\ mm$ ✓

$\therefore$ Provide 8mmϕ Lateral ties

pitch = (i) 450mm

(ii) $16 \times 16 = 256\ mm$ ✓

(iii) 300mm

$\therefore$ Provide 8mmϕ lateral ties @ 250mm c/c